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A comparative study: Futuristic simulation and traditional methods within the sustainable and energy-efficient architecture planning

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Abstract

Sustainable architecture has become a very important area of interest, which is focused on energy-efficient design principles and responsible management of environmental resources. The present research makes a comparative study of sustainable architectural buildings in the framework of futures studies and sustainable energy architectural modeling. Its main objective is to test the effectiveness of scenario-based futures studies in comparison with conventional approaches for formulating strategic foresight in sustainable architecture. The findings suggest that methodologies employed in future studies produce outcomes that are both more effective and more representative of real-world applications. This research adopts a mixed-method approach, integrating qualitative and quantitative analyses to evaluate traditional architectural practices against those emerging from future study scenarios. The approach is mixed methodological, in that it integrates wide literature reviews, a SWOT analysis, and the framing of ten scenarios and strategies within the realm of energy-efficient and renewable systems. Graphical modeling highlights these findings, showing the interlinkages between adaptability, innovation, and environmental outcomes. The study provides actionable insights for policymakers, architects, and researchers working to advance sustainable design paradigms. The study reveals methodologies of the futures approach significantly enhance strategic planning and execution in the development of sustainable architectural designs. Scenario-based approaches are more flexible and provide stronger frameworks, aligning better with real-life dynamics and the uncertainties of the future.

Graphical Abstract

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1. Introduction

Architecture focuses on the future, adapting to changes in society, technology, and the environment. Traditional planning methods often have difficulty handling uncertainties and rapid changes. This paper explores how scenario-based foresight from futures studies can enhance architectural planning and design, aiming for sustainability, innovation, and resilience over the long term. The idea of pursuing sustainable architecture is gaining momentum because there is a demand for eco-friendly and energy efficient designs for buildings. In particular, this paper intends to examine the benefits of modeling of sustainable architectures, particularly energy efficient ones, using the fusion of methodologies of futuristic studies. The architectural profession deals with matters of artistic expression, scientific investigation, and social context, working in response to the mutable requirements of humanity, technological advancement, and emergent environmental imperatives. In the face of mounting global pressure from rapid urbanization, climate change, and social and economic polarization, deterministic and rigid forms that define conventional architectural planning approaches are steadily sounding more and more inadequate. Such approaches typically favor the short-term view or quick fixes, disregarding the complex and uncertain process of long-term planning and environmental changes that emerge over time [1,6]. Therefore, creative approaches are required in the discipline of architecture that may skillfully navigate these uncertainties to achieve the designs capable of aligning with sustainable and inclusive futures.

In this regard, foresight and futures studies have emerged as major tools that enable architects and planners to prognosticate, understand, and influence changes in the future. Rooted in many disciplinary standpoints, these analyses also build on scenario planning, trend analysis, and participatory foresight methods to look at several potential scenarios of the future. For instance, [2] emphasize that strategic foresight tools, such as back casting, enable architects to design while thinking about future social needs and technological advances. It is well recognized now that foresight in architecture goes further than the meeting of inherent design criteria; the built environment must be made viable over the long term.

1.1. Background

There is an increasing body of research that supports the notions of adaptability and resilience in architectural design. [3] assert that the integration of futures thinking within the realm of sustainable architecture not only improves resource utilization but also guarantees the functionality of buildings and urban systems across various potential future scenarios. This methodology is consistent with international frameworks, including the United Nations’ Sustainable Development Goals (SDGs), which highlight the importance of incorporating foresight into architectural methodologies to meet wider societal aims. This study will rather broadly look into these dynamics, assessing what reach futures studies have for redesigning architectural planning and how successful they are in comparison with traditional approaches to respond to today's challenges. Returning to these concepts more specifically, participative foresight practices have come to the forefront as a way to advance architectural decision-making democratization. [4] holds that mutual scenario building—where various cohorts of stakeholders are part of the design process—leads to innovative and socially inclusive designs that are context-specific. This moves away from the top-down strategies and advances in alternative approaches of participative and anticipatory methodologies indeed bring the prospects of new possibilities for precisely tailoring architectural practices to the visions and needs of communities [5]. This paper attempts to lay a solid foundation for understanding how foresight methodologies could revolutionize architectural planning into a dynamic field with a future orientation by cross-integrating recent developments within the discipline.

1.2. Research questions

1. How does futures studies, when integrated, contribute to the development of sustainable architectural forms?
2. What are the relative advantages of scenario-based futures studies over conventional approaches to architectural planning?

1.3. Hypotheses

1. Futures studies give a more accurate and adaptable paradigm in modeling a sustainable architecture.
2. Scenario-based approaches produce better strategic foresight and implementation results than traditional methods.

2. Literature review

The paper looks into the junction of futures studies with architecture and critically analyzes methodologies, case studies, and theoretical advancements. It has evidently become significant in modern contemporary academic research not to exclude foresight in architectural practice in order to rightly address global issues like urbanization, climate change, and development of technology. Academics argue that futures studies provide a mutable framework for envisaging different potential futures which can help architects anticipate and address changes in societal needs. This chapter consolidates information from leading journals to give an in-depth understanding of the manner in which foresight methodologies are changing the ways of architectural planning and designing [6]. The research reviewed spans a broad spectrum of methodologies, such as scenario planning, strategic foresight tools, and methods in their participatory application, providing good insights into their application and implications in the built environment .The literature on sustainable architecture and energy efficiency is large; indeed, several research studies have underlined the essence of minimizing environmental impacts through innovative design and technological changes. This section discusses main contributions within the strands of sustainable architecture and energy-efficient design, and methods within futures studies.

Scenario Planning in Architecture: Jones and [7] explore the application of scenario planning to manage uncertainty in architectural design. They argue that scenario planning enables architects to create flexible strategies by visualizing multiple future pathways. Their case studies highlight its effectiveness in addressing urban development challenges under uncertain environmental and social conditions.

Strategic Foresight Tools: [8] provide an in-depth analysis of tools like Delphi studies, trend analysis, and back casting. They emphasize the role of these tools in aligning architectural designs with future societal needs, emphasizing sustainability and resilience. Their findings underline the importance of integrating quantitative and qualitative data for robust foresight.

Futures Thinking in Sustainable Architecture [9] discuss the integration of futures thinking into sustainable architectural practices. They illustrate how anticipatory frameworks can guide architects in creating eco-friendly and resource-efficient buildings. This study demonstrates the potential of futures studies in addressing climate change and resource scarcity.

Comparative Analysis of Planning Approaches: [10] provide a comparative study of traditional deterministic planning versus adaptive foresight methods. They conclude that adaptive foresight fosters innovation and flexibility, making it better suited for dynamic contexts like smart city development and urban regeneration.

Participatory Foresight in Architecture: [4] investigate the use of participatory foresight approaches, such as stakeholder workshops and collaborative scenario building. They highlight how involving diverse stakeholders enriches the design process, ensuring that projects reflect collective aspirations and address community-specific challenges.

2.1. Sustainable architecture

Sustainable architecture is a design philosophy that seeks to minimize the negative environmental impacts of buildings by enhancing efficiency and moderation in the use of materials, energy, and development space. Anderson and [11,12] argue that sustainable architecture not only addresses current environmental challenges but also improves the health and well-being of occupants. [13,14] emphasize the importance of using sustainable building materials and integrating renewable energy systems to reduce the carbon footprint of buildings.

2.2. Energy Efficiency in Architecture

Energy efficiency in architecture involves the design and construction of buildings that use less energy for heating, cooling, lighting, and other functions. [15 highlight that energy-efficient buildings can significantly reduce operational costs and environmental impact. [16] discuss various strategies for improving energy efficiency, including passive solar design, advanced insulation, and high-performance windows.

2.3. Renewable Energy Integration

The integration of renewable energy sources, such as solar, wind, and geothermal energy, into architectural design is crucial for achieving sustainability goals. [9] review the latest advancements in renewable energy technologies and their applications in building design. They suggest that the use of renewable energy not only reduces reliance on fossil fuels but also enhances the resilience of buildings to energy supply disruptions.

2.4. Futures Studies Methodologies

Methods of futures studies comprise the systematic investigation of potential and likely future circumstances, along with the formulation of strategies for realizing preferred results. Martinez and [17] explain the application of scenario planning and strategic foresight in the field of architecture to anticipate future challenges and opportunities. [18] highlight the advantages of employing futures studies in creating more adaptable and resilient architectural designs.

2.5. Comparative Analysis of Methodologies

A comparative critical analysis of futures studies and traditional methodologies identifies some fundamental differences in an approach to sustainable architectural design. Traditional approaches are more likely to place an emphasis on current technologies and practices, with a lower precedence for developing flexible strategies that is possible with foresight of future trends afforded in futures studies. For [19], futures studies afford a more integrative framework within which to consider the long-term sustainability of buildings.

3. Theoretical or experimental modeling

3.1. Methodology

This research aims to develop scenarios and strategies related to sustainable architecture and renewable energy-oriented buildings, using scientific foresight methodologies. By employing tools such as the Delphi method and Cross-Impact Matrix, key influential factors were identified and prioritized. Using Scenario Wizard software, potential scenarios were generated based on criteria like feasibility, strategic importance, and synergy. The results suggest that integrating sustainable architecture principles with renewable energy strategies provides a feasible path toward achieving a sustainable future.

Sustainable architecture and buildings based on renewable energy are considered among the most crucial responses to environmental and climate crises. The planned approaches turn down environmental wrongs and try to optimize energy along with comfort to give hope for a healthier and more sustainable future. The study has focused on three areas below:

1. Sustainable architecture.
2. Renewable energy-based constructions.
3. Unifying approaches that reflect both disciplines' ideas.

The main aim is to formulate scenarios and strategies that are in harmony with sustainable development objectives.

3.2. The Delphi Technique

The Delphi method is a systematic strategy used in collecting and assessing expert opinions. In this study, it was used to identify and prioritize key factors that impact sustainable architecture and structures based on renewable energy sources. The process took place in three main phases:

Stage 1: Initial Identification of Influential Factors

In the first stage, 20 experts from the fields of architecture, renewable energy, and policymaking participated in open-ended questionnaires to identify potential influencing factors. The aim was to capture a comprehensive set of elements affecting sustainability and renewable energy adoption.

The responses were analyzed, and 25 initial factors were identified, categorized into economic, social, technological, environmental, and policy-related domains.

Table1. The responses Category.

No.	Identified Factor	Category
1	Climate change	Environmental
2	Emerging technologies	Technological
3	Government policies	Policy-related
4	Consumer behavior	Social
5	Financial resources	Economic

Stage 2: Scoring the Influential Factors

In the second stage, the experts scored each identified factor based on two criteria: importance and uncertainty.

Scoring Methodology:

- Importance: 1 (low) to 5 (high)
- Uncertainty: 1 (low) to 5 (high)

Table2. Sample Scoring Table

Factor	Importance (1-5)	Uncertainty (1-5)	Average Score
Climate change	5	3	4.0
Emerging technologies	4	4	4.0
Government policies	5	5	5.0
Consumer behavior	4	3	3.5

Factor	Importance (1-5)	Uncertainty (1-5)	Average Score
Financial resources	5	4	4.5

Stage 3: Final Confirmation and Prioritization of Factors

In the third stage, the key factors were prioritized based on their average scores. These priorities were reviewed and confirmed during a group session with the experts.

Table3. Final Prioritized Factors

Rank	Key Factor	Average Score	Description
1	Government policies	5.0	Essential for guiding environmental and energy policies
2	Financial resources	4.5	Crucial for funding sustainable projects
3	Climate change	4.0	Requires rapid adaptation to environmental conditions
4	Emerging technologies	4.0	Influences design and resource management
5	Consumer behavior	3.5	Determines public acceptance of sustainable strategies

The Delphi process involved three stages:

1. Initial identification of key influencing factors.
2. Scoring factors based on importance and uncertainty.
3. Final prioritization and confirmation of key factors.

This process resulted in the identification of five key factors, which formed the foundation for scenario generation in this study.

a- Chart of Identified Factors Distribution by Category

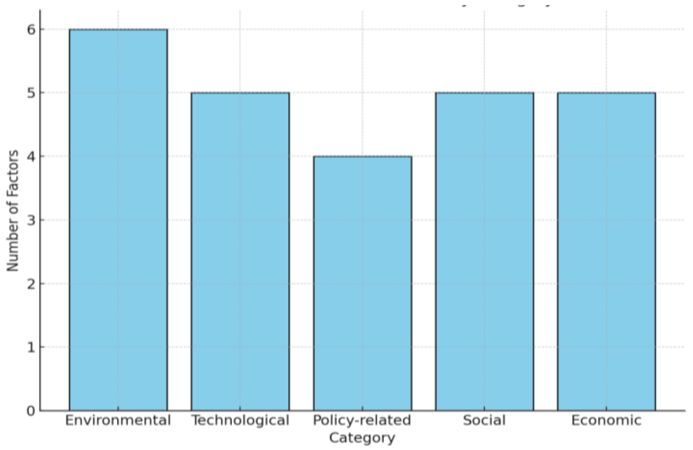

Fig. 1. Chart of Identified Factors Distribution by Category (Author)

This chart illustrates the number of identified factors across five main categories:

- Environmental (6 factors)

- Technological (5 factors)
- Policy-related (4 factors)
- Social (5 factors)
- Economic (5 factors)
- Interpretation:

The environmental category has the highest number of identified factors, reflecting its critical importance in sustainable architecture and renewable energy.

- The policy-related category has the fewest identified factors, but due to its high strategic impact, it was given significant attention in subsequent analysis.

b- Scatter Plot of Importance vs. Uncertainty

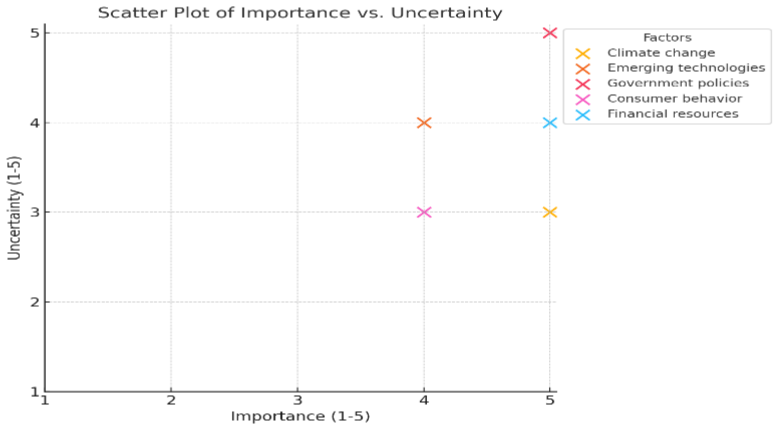

Fig. 2. Scatter Plot of Importance vs. Uncertainty (Author)

This chart depicts how key factors are distributed based on two criteria: importance and uncertainty. The main factors include:

- Government Policies: High importance and uncertainty (5, 5)
- Financial Resources: High importance (5) and medium uncertainty (4)
- Climate Change: High importance (5) and medium uncertainty (3)
- Emerging Technologies: Medium-high importance (4) and high uncertainty (4)
- Consumer Behavior: Medium importance (4) and lower uncertainty (3)

Interpretation:

- Factors such as government policies and financial resources are of utmost importance and uncertainty, requiring strategic focus as their changes can have widespread impacts.
- Consumer behavior, with medium importance and lower uncertainty, ranks lower but still holds significance in long-term strategies.

c- Bar Chart of Prioritized Key Factors

This chart ranks key factors based on their average scores (a combination of importance and uncertainty). The priority ranking is as follows:

- Government Policies (Average Score: 5.0)
- Financial Resources (Average Score: 4.5)

Advances in Energy Science and Technology
Vol. 1, No. 1|1 June 2025
AEST

- Climate Change (Average Score: 4.0)
- Emerging Technologies (Average Score: 4.0)
- Consumer Behavior (Average Score: 3.5)

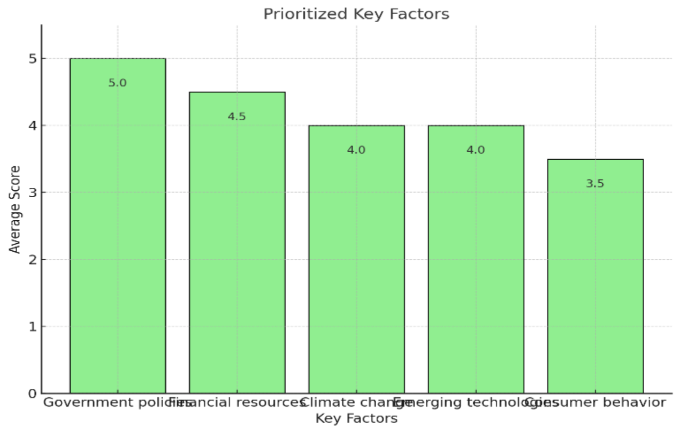

Fig. 3. Bar Chart of Prioritized Key Factors (Author)

Interpretation:

- Government policies rank as the top priority, highlighting their pivotal role in guiding sustainable development and renewable energy adoption.
- Financial resources rank second, emphasizing their direct impact on project implementation.
- Climate change, as a global challenge, occupies the third position.

Overall Conclusion from the Charts

Together, these three charts provided comprehensive analysis of the key factors, their relative priority and importance, and their role in the construction of foresight strategies. Factors with high importance and uncertainty were found to be the main driving forces for scenario development and strategic decisions.

4. The results and discussion

The results of this study demonstrate the significant advantages of incorporating futures studies methodologies into sustainable architectural design. Scenario planning and strategic foresight enable architects to develop more adaptable, resilient, and energy-efficient designs, addressing both current and future challenges.

Table 4. Comparative Analysis of Traditional and Future-Oriented Methodologies.

Aspect	Traditional Methods	Future-Oriented Methods
Focus	Current technologies and practices	Anticipation of future trends and challenges
Flexibility	Limited	High
Adaptability	Low	High
Environmental Impact	Moderate	Low
Cost Efficiency	Variable	High
Long-term Sustainability	Moderate	High

Table 5. Scenario-Based Strategies Related to "Sustainable and energy Efficiency Architecture.

No	Scenario	Expected Outcome	Description
1	Advanced Insulation	Reduced energy consumption for heating and cooling	Use of cutting-edge insulation materials
2	High-Performance Windows	Improved thermal comfort and reduced energy costs	Installation of energy-efficient windows
3	Passive Solar Design	Enhanced energy efficiency and occupant comfort	Designing buildings to utilize natural sunlight
4	Smart Building Systems	Optimal energy usage and reduced operational costs	Integration of smart technologies for energy management
5	Renewable Energy Integration	Increased use of clean energy and reduced carbon footprint	Use of solar panels and wind turbines
6	Green Roofs	Improved insulation and stormwater management	Installation of vegetated roofs
7	Energy-Efficient HVAC Systems	Reduced energy consumption and improved indoor air quality	Use of advanced heating, ventilation, and air conditioning systems
8	Water Conservation Techniques	Reduced water usage and operational costs	Implementation of water-saving fixtures and systems
9	Building Envelope Optimization	Improved energy efficiency and occupant comfort	Enhancing the thermal performance of building envelopes
10	Energy Storage Solutions	Enhanced energy resilience and reduced dependency on the grid	Integration of energy storage systems

Table 6. Scenario-Based Strategies Related to "Buildings with Renewable Energy Approach"

No	Scenario	Expected Outcome	Description
1	Solar Panel Installation	Increased renewable energy production	Installation of photovoltaic panels
2	Wind Turbine Integration	Diversified renewable energy sources	Use of small-scale wind turbines
3	Geothermal Heating and Cooling	Reduced reliance on fossil fuels	Utilization of geothermal energy for temperature regulation
4	Biomass Energy Systems	Sustainable energy production from renewable sources	Use of organic materials for energy production
5	Solar Water Heating	Reduced energy consumption for water heating	Installation of solar water heating systems
6	Hybrid Renewable Systems	Enhanced energy reliability and efficiency	Combination of multiple renewable energy sources
7	Microgrid Implementation	Improved energy security and resilience	Development of localized energy grids
8	Energy Management Systems	Optimal energy utilization and reduced waste	Use of advanced systems for monitoring and managing energy usage
9	Net-Zero Energy Building Design	Achieving complete energy self-sufficiency	Designing buildings to produce as much energy as they consume
10	Policy and Incentive Programs	Increased uptake of renewable energy technologies	Implementation of supportive policies and incentives for renewable energy adoption

Table 7. Strategies and Scenarios Related "Sustainable and energy Efficiency Architecture"

No.	Strategy/Scenario	Objective	Description
1	Reducing Energy Consumption in Building Design	Conserving Natural Resources	Focus on minimizing energy loss through sustainable building materials.
2	Using Local and Recyclable Materials	Reducing Carbon Footprint	Reducing transportation needs and reliance on newly manufactured materials.
3	Optimizing Natural Ventilation	Increasing Thermal Comfort	Designing buildings with respect to climate and natural airflows.
4	Incorporating Green Spaces into Buildings	Improving Quality of Life	Enhancing interaction with nature via green roofs and green walls.
5	Utilizing Natural Lighting	Reducing Energy Consumption for Lighting	Designing windows and using insulated glass for effective light capture.
6	Employing Climate-Responsive Design Techniques	Optimizing Energy Consumption	Analyzing the climatic conditions of the area in building design.
7	Developing Educational Programs on Sustainable Design	Raising Awareness	Empowering architects and engineers for sustainable design.
8	Designing Multipurpose Buildings	Efficient Space Utilization	Integrating multiple functions to reduce construction and energy costs.
9	Reducing Water Consumption in Buildings	Managing Water Resources	Implementing rainwater harvesting and graywater recycling systems.
10	Flexible Design for Future Changes	Enhancing Building Longevity	Creating adaptable buildings that meet future needs.

Table 8. Strategies and Scenarios "Buildings with Renewable Energy Approach"

No.	Strategy/Scenario	Objective	Description
1	Installing Solar Panels	Producing Clean Energy	Harnessing solar energy to meet the electrical needs of the building.
2	Utilizing Geothermal Systems	Enhancing Energy Efficiency	Providing heating and cooling through geothermal sources.
3	Developing Energy Storage Batteries	Ensuring Energy Sustainability	Storing produced energy for use during peak demand periods.
4	Designing Zero-Energy Buildings	Reducing Fossil Fuel Dependency	Producing all the energy required by the building on-site.
5	Integrating Smart Energy Management Systems	Increasing Energy System Efficiency	Using sensors for optimized energy management.
6	Harnessing Small-Scale Wind Energy	Utilizing Other Clean Energy Sources	Installing small wind turbines on buildings.
7	Optimizing Energy Use with Advanced Insulation	Reducing Heating and Cooling Needs	Preventing energy loss through building envelopes.
8	Employing Heat Pump Systems	Improving Energy Efficiency	Efficiently transferring heat from natural sources.
9	Combining Renewable Energy Sources	Providing Flexibility in Energy Supply	Simultaneous use of solar, wind, and geothermal energy.
10	Participating in Smart Energy Grids	Reducing Pressure on Traditional Grids	Transferring excess energy to smart electricity grids.

Table 9. Combined Strategies and Scenarios (Integrated Approach)

No.	Strategy/Scenario	Objective	Description
1	Designing Zero-Energy Buildings with a Sustainable Approach	Reducing Carbon Emissions	Utilizing renewable energy in sustainably designed buildings.
2	Establishing Multifunctional Environmental Complexes	Enhancing Social and Environmental Interaction	Integrating green spaces with low energy consumption and climate-responsive design.
3	Integrating Smart Technology for Sustainable Energy Management	Enhancing Efficiency	Managing energy resources using advanced technologies.
4	Using Sustainable Materials in Renewable Energy Buildings	Reducing Environmental Impact	Using recycled and local materials alongside clean energy production.
5	Developing Economic Incentive Policies	Accelerating Sustainable Projects	Providing loans and financial support for integrated projects.
6	Strengthening Research and Development Infrastructure	Advancing Technology	Investing in sustainable and renewable energy technologies.
7	Designing for the Future	Enhancing Adaptability	Creating buildings that respond to evolving future needs.
8	Comprehensive Water and Energy Resource Management	Optimizing Resources	Implementing smart systems to reduce water and energy consumption.
9	Raising Public Awareness	Changing Consumer Behavior	Educating people about the benefits of sustainable and renewable energy buildings.
10	Enforcing Stringent Regulations for Sustainable Development	Ensuring Strategy Implementation	Approving mandatory regulations for sustainable and clean energy buildings.

These results from the present research have critical real-world implications that establish an urgent need for a profound paradigm shift in architectural design planning towards more forward-thinking and anticipatory approaches. Methods related to futures studies can integrate flexibility and robustness into buildings designed for sustainability. In this way, architects will design based on future concerns and hurdles, hence creating strategies that do not just address current sustainability objectives but also prepare them for long-term physical and environmental changes.

Acceptance of scenario planning in the design framework is another major positive factor of the methodologies employed in futures studies. Scenario planning allows architects to consider various alternative futures and to develop flexible strategies that will fit under different circumstances. This technique is particularly relevant in energy efficiency and integration of renewable energy due to the fact that technological advance or regulation changes are bound to bring considerable fluctuations in the design choice options.

For instance, in architecture, scenario planning could help architects design buildings that could survive future gains in energy prices or future tougher environmental legislation. This means that architects should be able to design for the long-term effectiveness and cost efficiencies of energy-efficient technologies and renewable energy systems. In contrast, regular methodologies do not often focus on current technologies and practices alone but rather neglect future developments that might appear.

More so, advanced technologies such as intelligent building systems, energy management frameworks, and automated building controls can enhance the sustainability of architectural designs in a huge manner. These enhance real-time observations with optimal energy consumption, leading to a tremendous cut in energy usage and the costs related to operation in the built environment. Besides, the use of renewable energy sources such as solar photovoltaic panels and wind energy turbines can greatly help in the reduction of carbon emissions in relation to buildings, ultimately working for general environmental sustainability.

The discussion also elucidates that the need for joint action among policymakers, architects, and technologists. Realization of positives from the application of methodologies of futures studies depends on a policy conducive atmosphere besides environmental exposure towards advanced technological means. The policymakers can centrally motivate the provision of incentives for sustainable design and integration of renewable energy while instituting appropriate regulations.

6. Conclusion

The use of scenario-based foresight in architectural planning is part of an integrated approach to managing uncertainty and ensuring long-term sustainability. Future research should focus on the development of standard methods along with programs seeking to improve the skills of architects.

- Scenario-Based Foresight: Best suited for projects with high uncertainty and long-term horizons, particularly in urban planning and sustainable architecture.
- Traditional Planning: Suitable for routine projects with well-defined parameters.
- Combined Approach: A hybrid model integrating foresight tools with traditional planning frameworks can maximize strengths while mitigating weaknesses.

Table 10. Comparative Evaluation.

Criteria	Scenario-Based Foresight	Traditional Planning
Flexibility	High: Adapts to uncertain futures	Low: Assumes stable conditions
Stakeholder Engagement	Inclusive: Emphasizes participatory processes	Limited: Focused on expert-driven models
Innovation Potential	High: Encourages creative exploration	Moderate: Constrained by existing frameworks
Implementation Complexity	High: Requires expertise and resources	Low: Well-understood and standardized
Cost Efficiency	Variable: Long-term benefits offset higher initial costs	Consistent: Predictable and budget-friendly

Table 11. Conclusion of SWOT Analysis.

Factor	Scenario-Based Foresight	Traditional Planning
Strengths	Adaptability, stakeholder alignment	Simplicity, cost predictability
Weaknesses	Resource-intensive, complex processes	Limited flexibility, siloed decision-making
Opportunities	Future-proof designs, sustainability	Incremental improvements
Threats	Implementation resistance, expertise gaps	Irrelevance in dynamic contexts

This study highlights the significant advantages of incorporating futures studies methodologies into sustainable architectural design. By comparing traditional methods with future-oriented approaches, the research demonstrates that scenario planning and strategic foresight can lead to more adaptable, resilient, and energy-efficient buildings. The key findings and implications of this study are summarized below:

1. Enhanced Flexibility and Robustness: Futures studies methodologies empower architects to be able to foresee and be ready for upcoming challenges so that their designs have greater flexibility and are more robust. This is at great contrast to the present-day approach, which often leaves future uncertainties poorly accounted for.

2. Energy Efficiency: Advanced building technologies and renewable energy systems can be integrated into buildings to enhance their energy efficiency. According to the scenario-based strategies applying integrative, smart building systems and energy-efficient HVAC systems integrated with renewable energy, ways can be reduced in the operational costs.
3. Long Term Sustainability: Futures studies basically indicate the long-term viability of processes by considering future trends and shocks. It will encourage the practice of using sustainable construction material, energy-efficient technologies, and renewable energy sources, leading to reduced environmental impacts and better well-being of the occupants.
4. Collaboration and Policy Support: Implementing futures study methodologies effectively will need collaborative efforts from architects, policymakers, and technologists. Relevant and supportive policies in, for example, sustainable design and the integration of renewable energies, would come out as significant game-changers.

6.1. Summary of Key Findings

Summary of Key Findings: The flexibility and resilience of future-oriented methods render buildings fit and prepared for increased energy efficiency, while being ready to meet future challenges and uncertainties. For example, such strategies include smart systems in buildings and better insulation that considerably lowers energy consumption and the cost of operation.

• Installation of renewable energy systems well supported by design innovativeness helps much in enhancing clean energy use and lowering carbon release.

• Sustainable design that is successful requires collaboration of the architect, policy makers, and technologists among the establishment of supportive policy and incentive setting.

The broad analysis given in this paper underscores the direction toward methodologies applied in the work of an architect, which is future-minded in sustainable architectural design: through its practice, a structure would not only be capable of sustaining the demands of the environment but also future challenges. More research and working together is required to realize the potential of futures studies methodologies to create a sustainable built environment.

6.2. Findings in Brief

1. Improved Adaptability and Resilience get Description: Future-oriented approaches enable architects to foresee and plan for possible future situations, resulting in buildings that are resilient to change and challenges like climate change, technological evolution, and societal changes. Implication: This leads to buildings with increased lifespans, lower maintenance expenses, and improved occupant satisfaction.
2. Enhanced Energy Efficiency: get Description: The use of advanced insulation, intelligent building systems, and energy-efficient HVAC systems can greatly minimize energy use. Implication: This leads to lower energy bills, reduced carbon footprints, and compliance with stricter energy regulations.
3. Extensive Renewable Energy Integration: Description: Integrating renewable energy sources like solar panels, wind turbines, and geothermal systems ensures a sustainable energy supply. Implication: This reduces dependency on fossil fuels, mitigates environmental impacts, and supports energy security.
4. Long-term Sustainability: Description: Considering future trends in materials, technologies, and environmental conditions ensures that buildings remain sustainable over time. Embedding: This will contribute to the overall reduction in greenhouse gas emissions and the health and well-being of its occupants.

5. Collaboration and Policy Support: Embedding: The successful practice of these techniques engrains the collaboration between architects, policymakers, and technology providers. Implication: Policies and incentives can accelerate and facilitate the wide application and viable integration of the sustainable practices or technologies.

6.3. Jerome's Input Conclusion

The integration of a methodology for futures studies into the sustainable architectural design field represents a critical shift from conventional approaches. The present study, therefore, postulates that futures methods that emphasize a gaze result in more flexible, resilient, energy-efficient, and sustainable structures. Their successful implementation would result from the cooperation of the various players involved and policy support. This further calls for continuous research workout and innovation infusing the changing needs of sustainability in architectural practice.

6.4. Recommendations for Future Research

1. Integration of Emerging Technologies: Ongoing research into the application of emerging technologies, such as artificial intelligence and the Internet of Things, in enhancing building efficiency.
2. Policy Development: Research into effective policy frameworks and incentives that may encourage the widespread adoption of sustainable practices.
3. Longitudinal Studies: Long-term research to measure the impact and benefits of structures designed using future studies approaches.
4. Interdisciplinary Collaboration: Promoting alliances among architects, engineers, policymakers, and technologists to further advance comprehensive and inventive solutions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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